Evaluating Salinity Trends in the Delta Using Data from 1922-2012

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Funding: San Luis and Delta Mendota Water Authority and State Water Contractors

Additional Support: Joey Zhou, Tara Smith, and Eli Ateljevic, Department of Water Resources

Presentation to the DSM2 Users Group

May 14, 2014

Overview

- Data sources
- DSM2 estimates in support of data adjustment
- Adjustment and cleaning to develop a daily average time series of salinity
- Trend evaluation by
  - Isohalines (X2 and other positions)
  - Stations along the salinity gradient
- Use of these data to inform modeling

Data Sources

- DWR bulletins with grab sample chloride data, spanning 1922 to 1971 (referred to as Bulletin 23)
- CDEC measurements of salinity as electrical conductivity, reported sub-daily, 1964-2012
- Goal: integrate both data sources and develop a continuous daily time series of salinity across multiple stations in the western Delta

DWR Bulletin Data

- Manually transcribe chloride/chlorinity data from selected bulletins (scanned paper copies)
- Convert to georeferenced Access database
- Measurements usually at higher high tide (HHT), but not always
- Need to convert to daily average values

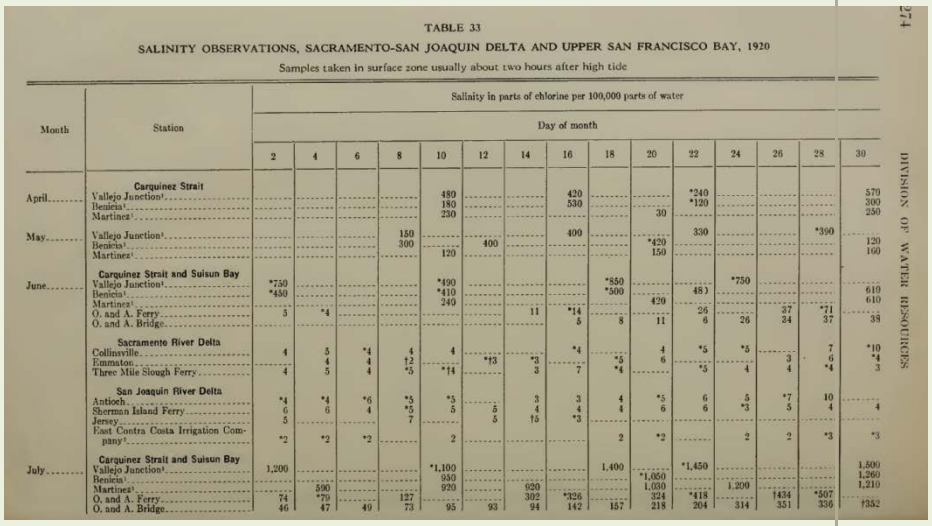
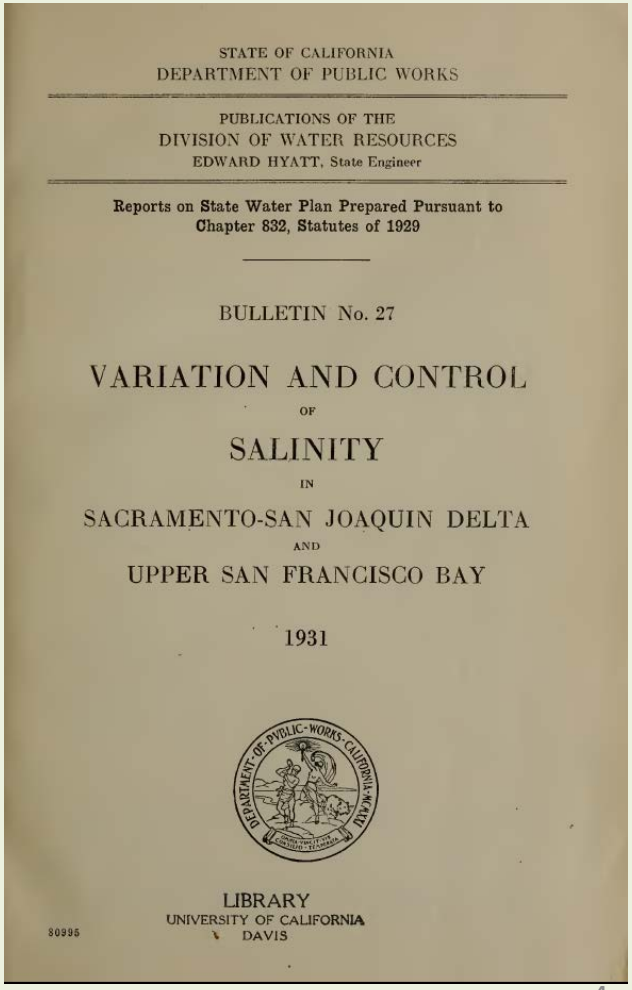


TABLE 33

SALINITY OBSERVATIONS, SACRAMENTO-SAN JOAQUIN DELTA AND UPPER SAN FRANCISCO BAY, 1920

Samples taken in surface zone usually about two hours after high tide

Month	Station	Salinity in parts of chlorine per 100,000 parts of water — Day of month													
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	Carquinez Strait															
April	Vallejo Junction[1]					480			420			*240				570
	Benicia[1]					180			530			*120				300
	Martinez[1]					230					30					250
May	Vallejo Junction[1]				150				400			330			*390	
	Benicia[1]				300		400				*420					120
	Martinez[1]					120					150					160
	Carquinez Strait and Suisun Bay															
June	Vallejo Junction[1]	*750				*490				*850			*750			
	Benicia[1]	*450				*410				*500		480				610
	Martinez[1]					240					420					610
	O. and A. Ferry	5	*4					11	*14			26		37	*71	
	O. and A. Bridge								5	8	11	6	26	34	37	38
	Sacramento River Delta															
	Collinsville	4	5	*4	4	4			*4		4	*5	*5		7	*10
	Emmaton		4	4	12		*13	*3		*5	6			3	6	*4
	Three Mile Slough Ferry	4	5	4	*5	*14		3	7	*4		*5	4	4	*4	3
	San Joaquin River Delta															
	Antioch	*4	*4	*6	*5	*5		3	3	4	*5	6	5	*7	10	
	Sherman Island Ferry	6	6	4	*5	5	5	4	4	4	6	6	*3	5	4	4
	Jersey	5			7		5	15	*3							
	East Contra Costa Irrigation Company[1]	*2	*2	*2		2				2	*2		2	2	*3	*3
	Carquinez Strait and Suisun Bay															
July	Vallejo Junction[1]	1,200				*1,100				1,400		*1,450				1,500
	Benicia[1]					930					*1,050					1,260
	Martinez[1]		590			920					1,030		1,200			1,210
	O. and A. Ferry	74	*79		127			920			324	*418		434	*507	
	O. and A. Bridge	46	47	49	73	95	93	94	142	157	218	204	314	351	336	†352



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS

PUBLICATIONS OF THE
DIVISION OF WATER RESOURCES
EDWARD HYATT, State Engineer

Reports on State Water Plan Prepared Pursuant to Chapter 832, Statutes of 1929

BULLETIN No. 27

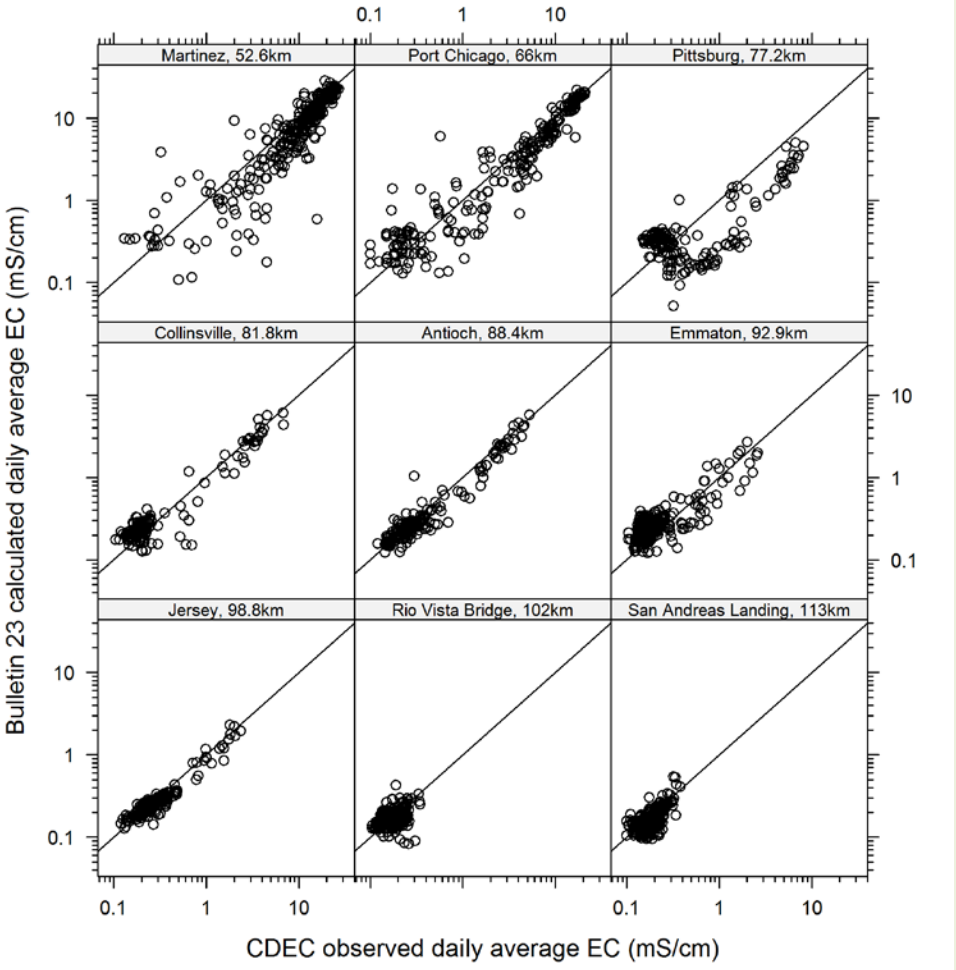
VARIATION AND CONTROL OF SALINITY IN SACRAMENTO-SAN JOAQUIN DELTA AND UPPER SAN FRANCISCO BAY

1931

Correction for Higher High Tide (HHT) Salinity

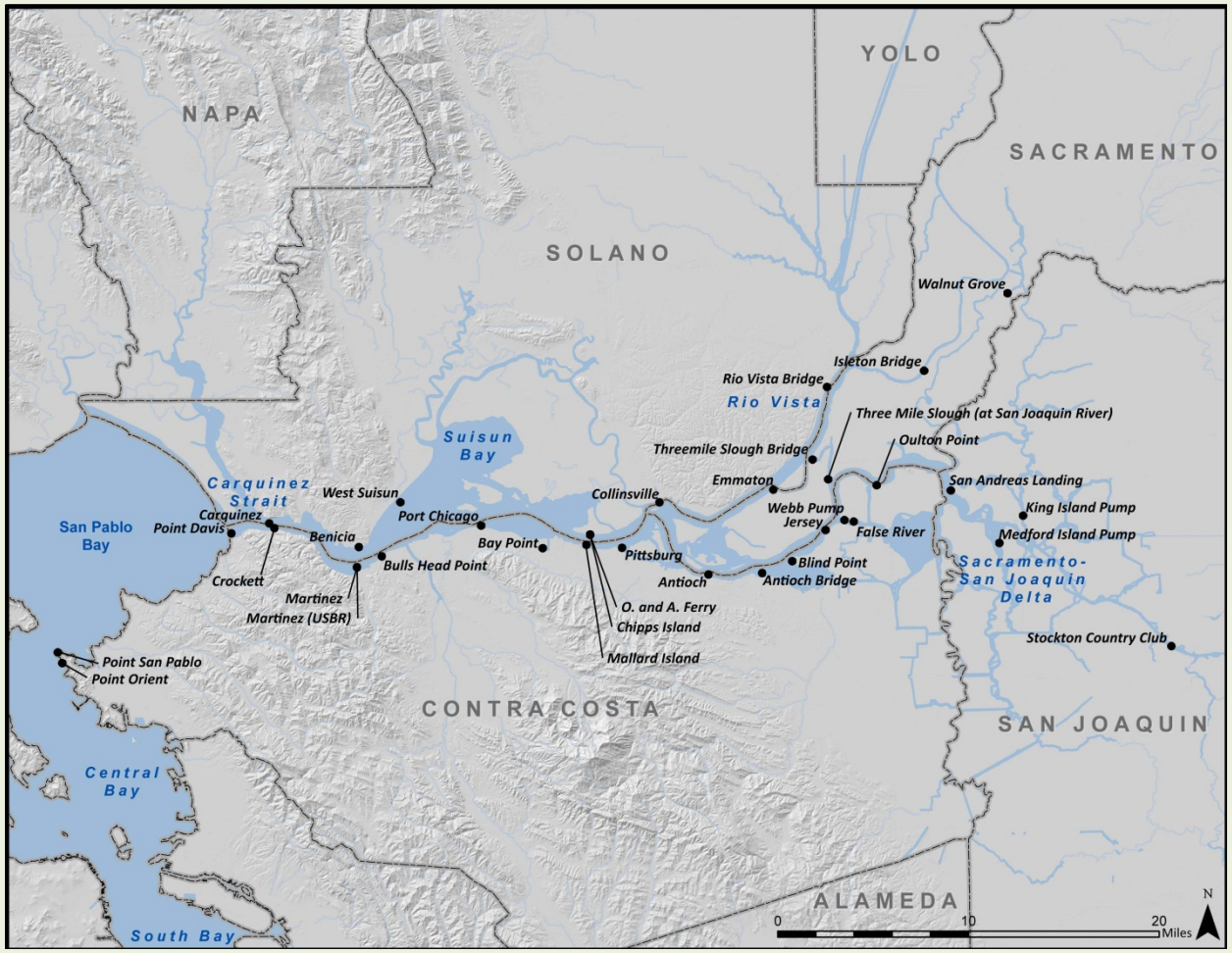
- DSM2 was run over 1922 to 1976 (Acknowledgement: Joey Zhou and Tara Smith, DWR)
- Daily values of ratio of EC at HHT to average EC were computed
- Observed grab sample data corrected using ratios obtained from DSM2
- The approach can be validated over 1964-1971 when both Bulletin 23 and CDEC data are available
- The DSM2 method was as good as or better than other competing methods and was used because of it ability to represent conditions beyond the validation period.

Comparison of Daily Averaging



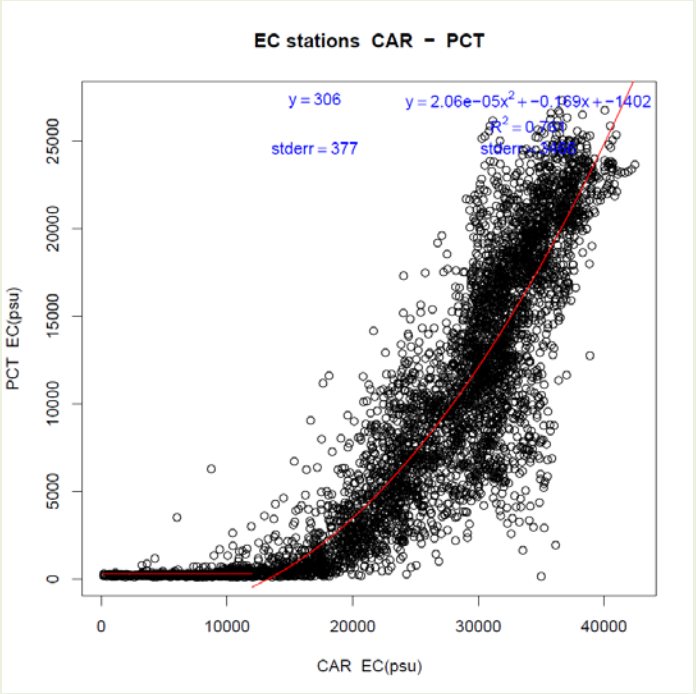
Pittsburg Bulletin 23 data excluded from analysis.

Combination of Bulletin 23 and CDEC Stations Used in Analysis

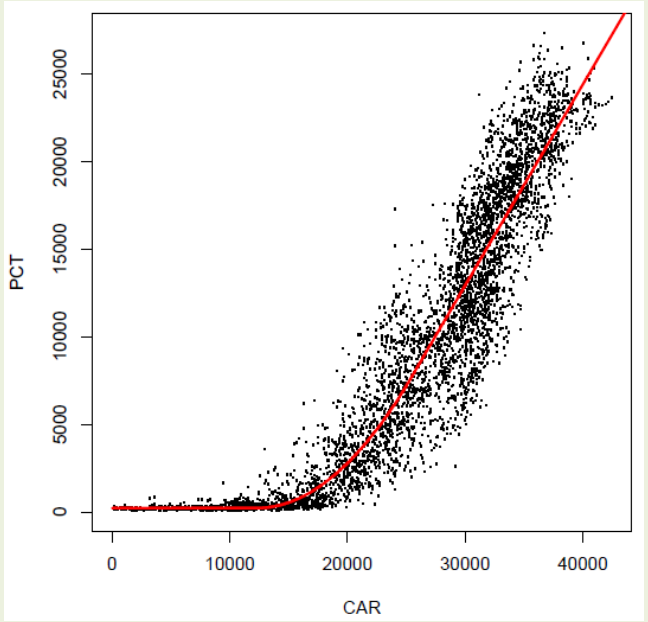


CDEC Data Cleaning Example

(Additional Support for this Task: Joey Zhou and Tara Smith, DWR)



Original Data

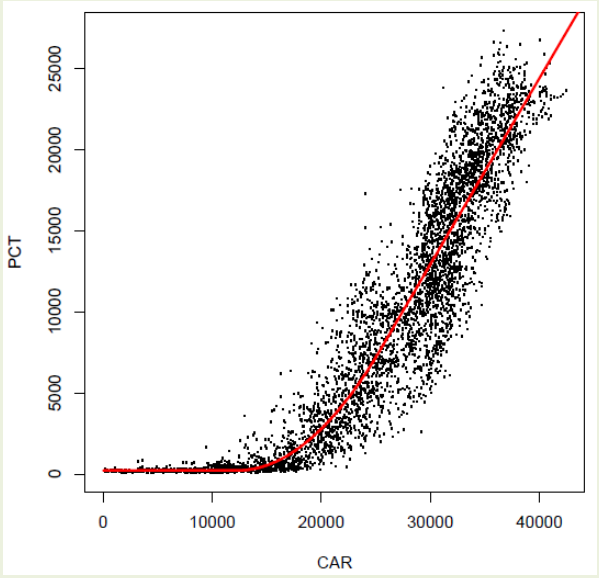


Cleaned Data

Procedure repeated over all neighboring station pairs

Data Filling Example

Port Chicago
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
B11
B12
B13
B14
B15
B16
B17
B18
B19
B20
B21
B22
B23
B24
B25

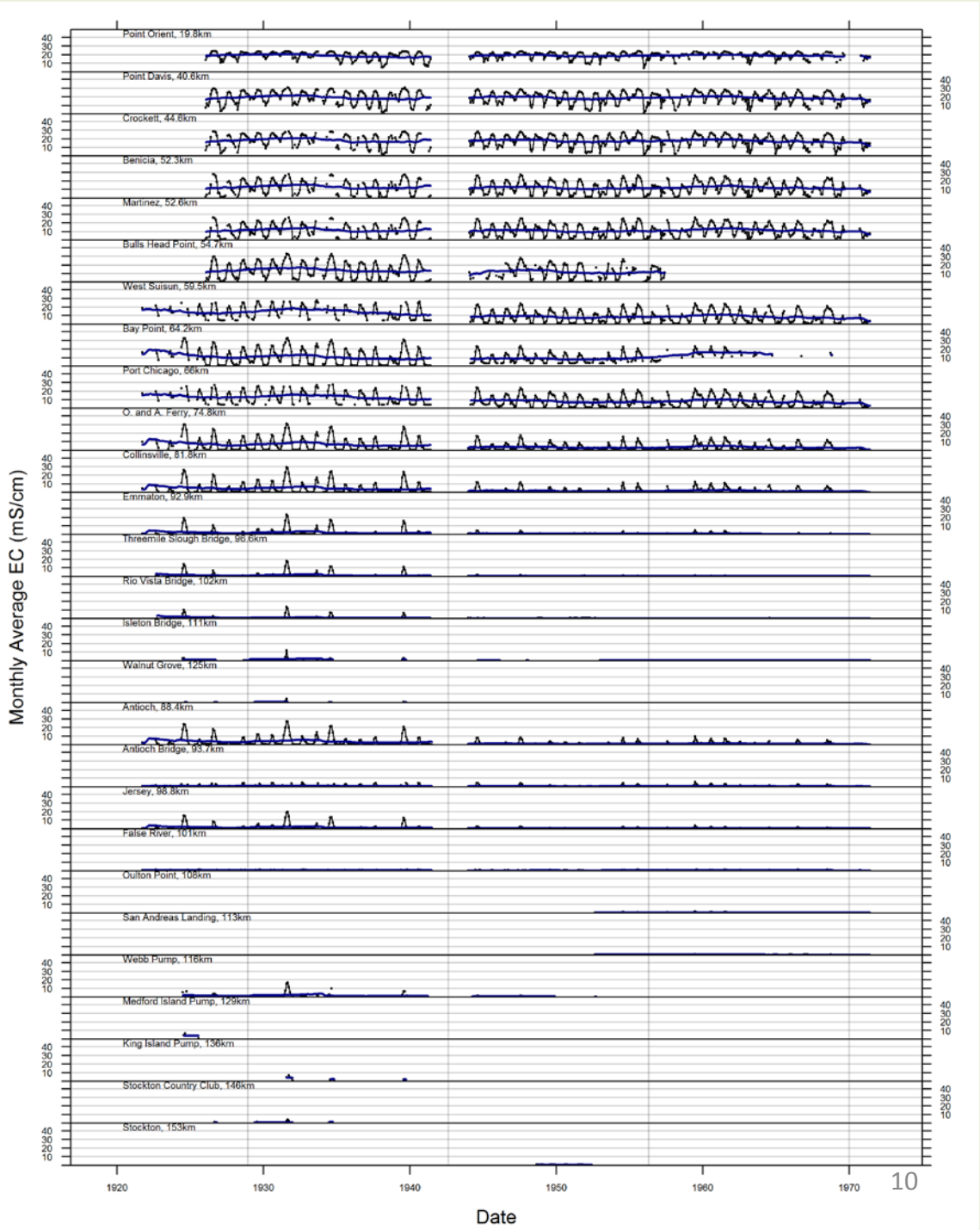


Carquinez
A1
A2
A3
A4

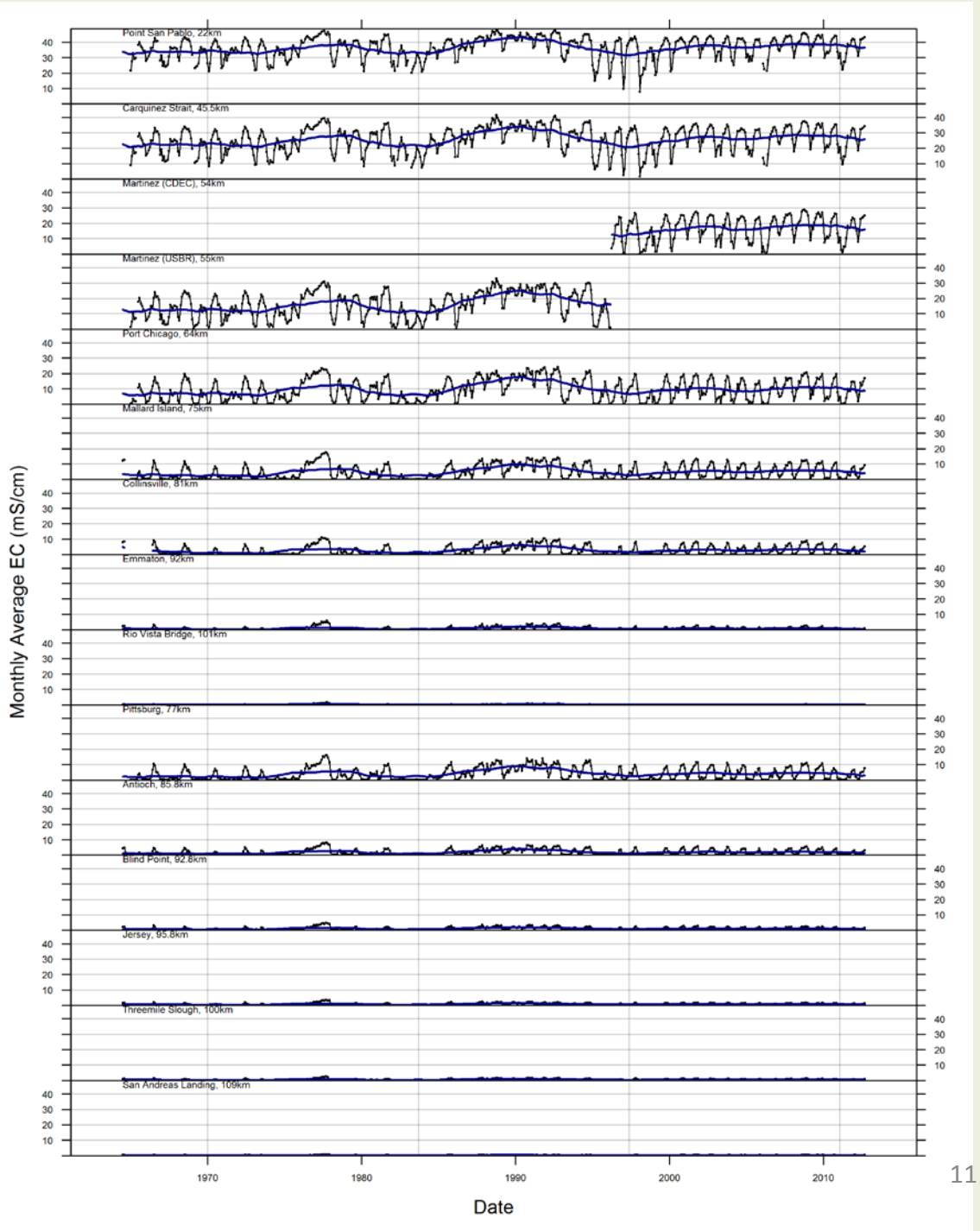
Linear interpolation

Neighbor filling

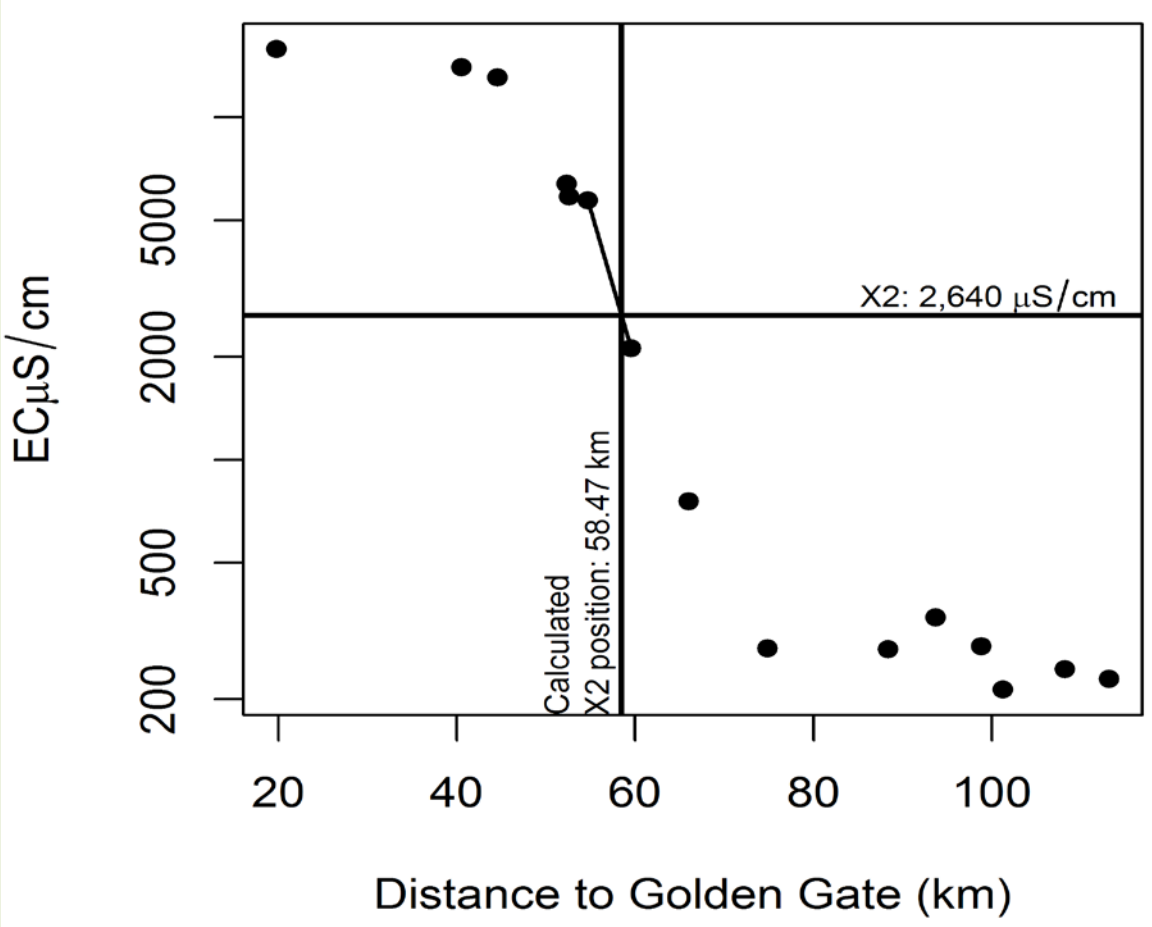
Bulletin 23 Data (Cleaned and Filled)



CDEC Data (Cleaned and Filled)

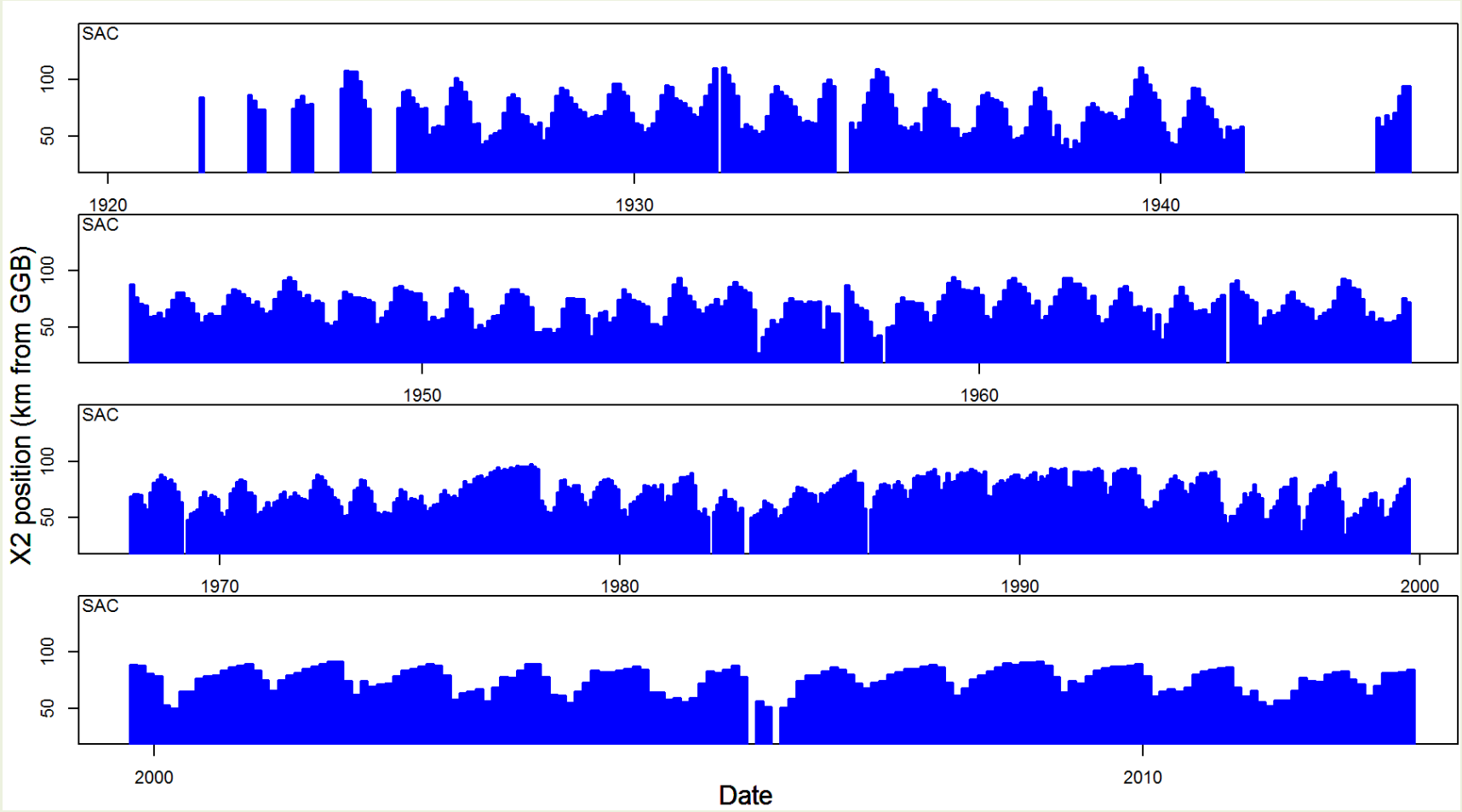


Isohalines Positions Interpolated from Station Data

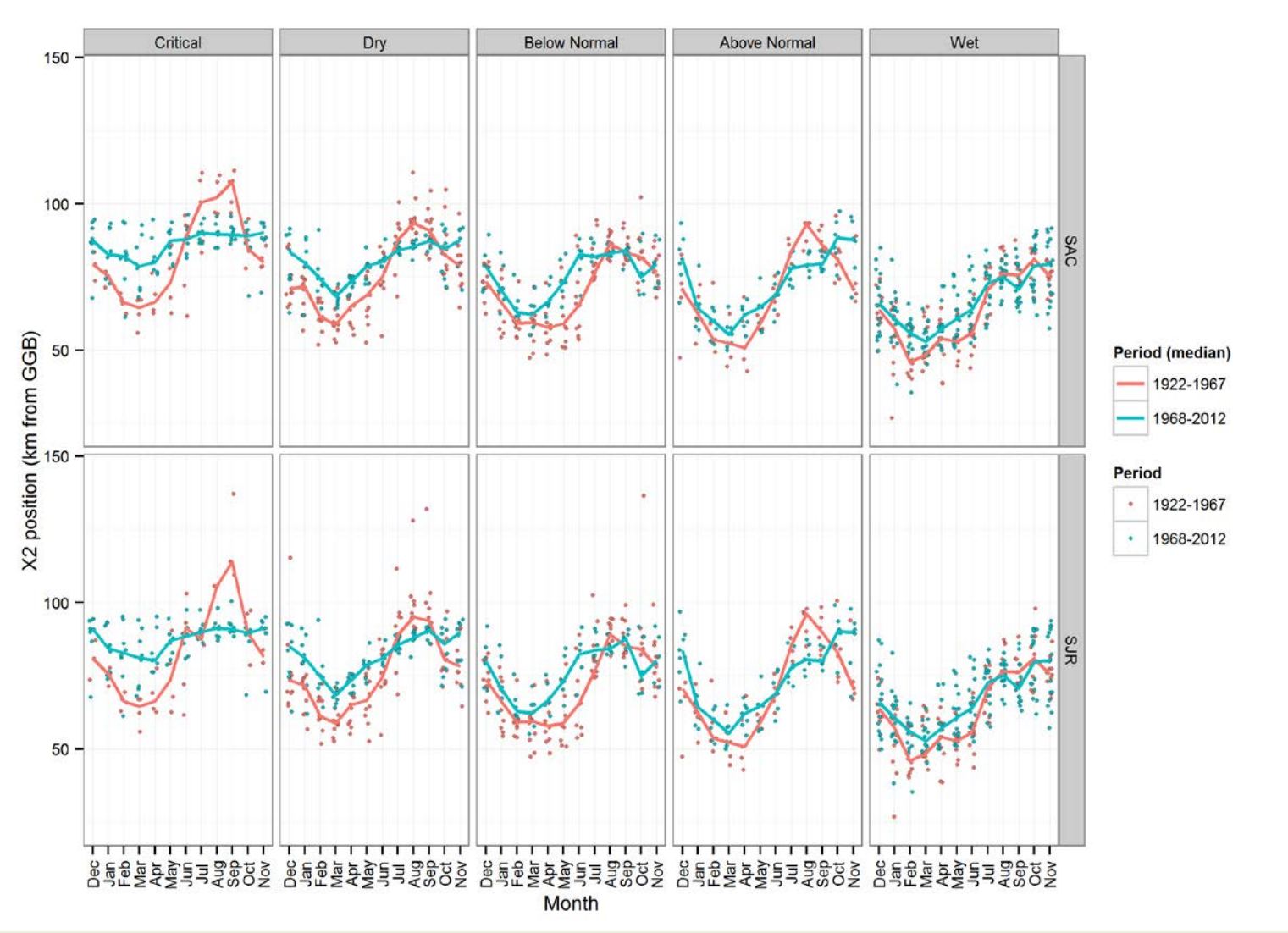


Use log EC-linear distance between bounding stations to compute isohalines. X2 (2,640 μs/cm) is shown here.

X2 Over Time (Sacramento River)



X2 By Month and Water Year



Evaluation of Trends by Station EC and by Isohaline Position (Example: WY 1922-2012)

W ⟷ E

Month	Martinez	Mallard Is	Collinsville	Antioch	Jersey Point	SAC-X2	SJR-X2
Dec	↑	↑	↑	↑	↔	↑	↑
Jan	↑	↑	↔	↔	↔	↑	↑
Feb	↑	↑	↔	↔	↔	↑	↑
Mar	↑	↔	↔	↔	↓	↑	↑
Apr	↑	↔	↔	↔	↓	↑	↑
May	↑	↑	↔	↔	↓	↑	↑
Jun	↑	↔	↔	↔	↓	↑	↔
Jul	↑	↔	↔	↔	↔	↔	↔
Aug	↔	↓	↓	↓	↓	↓	↓
Sep	↑	↓	↓	↓	↓	↓	↓
Oct	↑	↔	↔	↔	↔	↔	↔
Nov	↑	↑	↑	↑	↔	↑	↑
All	↑	↑	↔	↔	↓	↑	↑

Use of Interpolated X2 to Inform Model Development

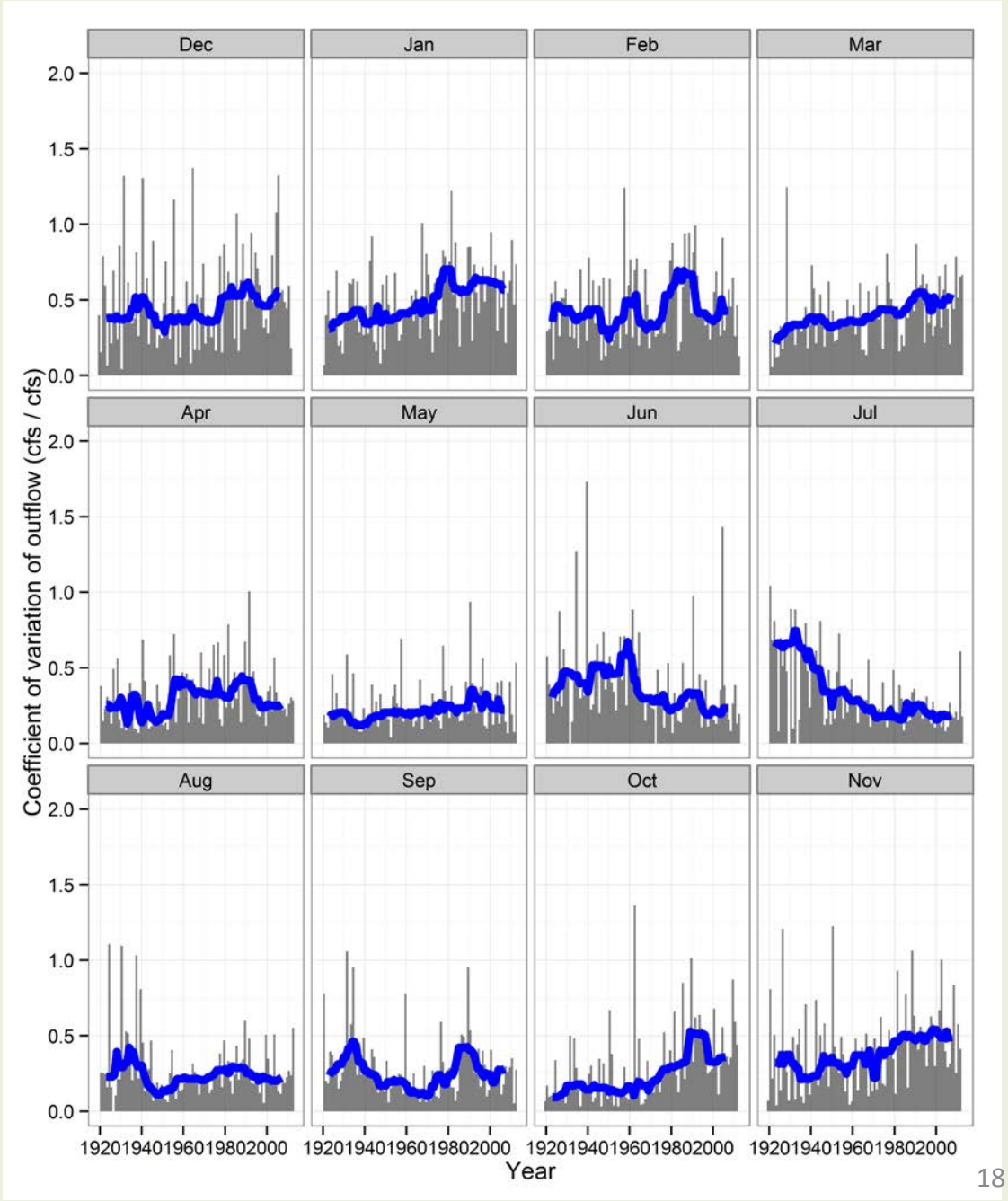
- A clean long-term salinity dataset is a good resource for improving existing models
- For example, the K-M model is based on data from 1967-1991:
  - $X2(t) = 122.2 + 0.328*X2(t-1) - 17.6 \log(Qout(t))$
- We can compare model performance with K-M model or recalibrate parameters

K-M Model Recalibration

$$X2(t) = A + B\,X2(t-1) - C\log(Q_{out}(t))$$

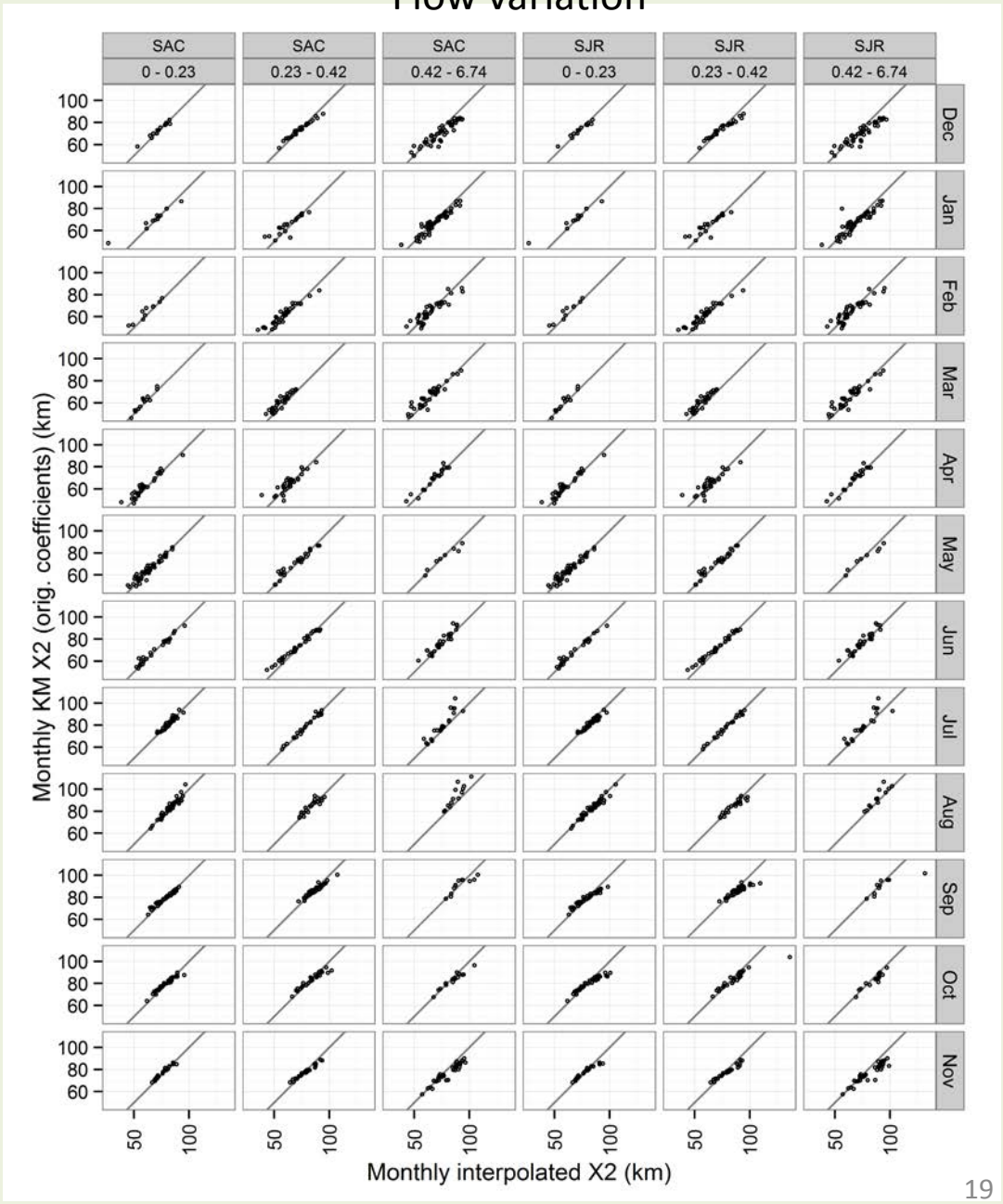
River	Period of Regression	r^2	Standard Error of Regression (km)	A	B	C
SAC	10/01/1921 to 09/01/2012	0.930	3.51	114. +/- 1.80	0.418 +/- 0.0106	-17.3 +/- 0.291
SAC	10/01/1921 to 06/01/1964	0.923	3.95	112. +/- 2.65	0.432 +/- 0.0158	-17.2 +/- 0.439
SAC	07/01/1971 to 09/01/2012	0.939	3.07	119. +/- 2.63	0.392 +/- 0.0153	-17.9 +/- 0.418
SAC	10/01/1967 to 11/01/1991 (K-M period)	0.948	2.79	110. +/- 3.36	0.419 +/- 0.0198	-16.2 +/- 0.517
	Original Published Model			122.2	0.328	-17.6

Coefficient of Variation of Delta Outflow*

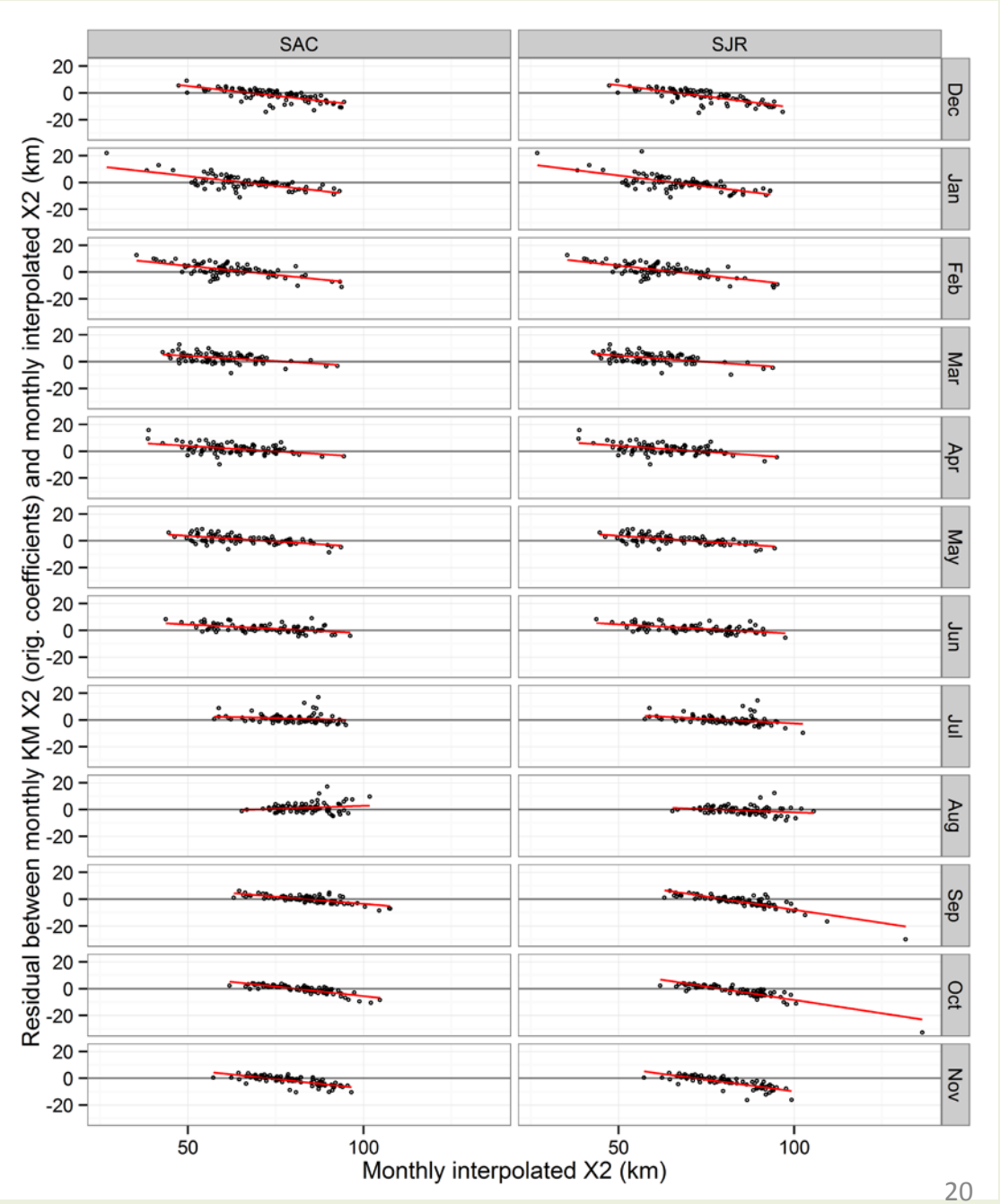


*Standard deviation divided by the mean of daily flows in a month

Effect of Flow Variation on K-M Model Performance



K-M Model Residuals



Summary

- This effort makes long-term salinity data collected over the past 9 decades amenable to analysis
- Cleaning the data was an extensive effort, and was needed for both the Bulletin 23 and CDEC datasets
- Can use this dataset to evaluate trends over specific types of flow conditions and also to calibrate and improve models
- In addition to the K-M model work shown here, this data set is being used for the development of a generalized salinity gradient model and artificial neural network models of salinity in the western Delta